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THE OUTLOOK FOR A BETTER CORRELATION OF SECONDARY SCHOOL AND COLLEGE INSTRUCTION IN CHEMISTRY[1]

IF the question "Should more credit be allowed by institutions of college grade for work in chemistry done by pupils in secondary schools?" were asked of any considerable number of teachers in those schools it is easy to believe that the majority would make an affirmative reply, and that all would at least be inclined to add to the query the traditional language of the examination paper, "If not, why not? Give reasons for your answer." Inasmuch as the present conditions with respect to the correlation of the work in the two grades of schools is admittedly unsatisfactory, and since these conditions are essentially determined by decisions on the part of the colleges, it is fitting that the situation should be occasionally reviewed, with the purpose of finding out, on the one hand, how far the present situation can be defended and, on the other hand, of seeking means by which better results can be attained. Others have dealt with this subject from various standpoints, and the statements which follow are made less with the expectation that anything like a final word will be said, than the hope that a contribution of the experiences of the teachers in one more laboratory, and a few of the conclusions which they have reached, may do something to aid in the comprehension of one of the most perplexing

[1] Presented at the second decennial celebration of Clark University, Worcester, Mass., September 17, 1909.

problems which confront the teacher of elementary chemistry to-day.

The experiences here recorded have been gathered from the routine of instruction in a technical school, and it may be considered doubtful by some whether observations made in the laboratory of a technical school in which the instruction in chemistry becomes a part of a "step up" system of requirements (that is, one in which successful work in subjects of later years is directly dependent upon a thorough grounding in earlier subjects to a degree that does not obtain in the less rigid sequence of studies in the college) should be taken as a basis for conclusions bearing also upon college work; but, while such doubts may be justified in the case of a limited number of institutions in which chemical instruction is merely a part of a general college course, it is increasingly true that more and more students from all colleges are seeking the technical schools to complete some of the professional courses which they offer. In the case of the university the technical school may well be a part of its own system; in the case of the college it means that its reputation for efficiency in teaching is to be unexpectedly tested by some other group of instructors, and it should be as much a matter of concern to them to see that their students have an adequate preparation in the sciences as to see that they are soundly taught in mathematics or the humanities. Many of the colleges have much room for improvement in this respect.

Let us first look at the situation as it apparently exists at present in some of our typical institutions as indicated by the following brief summaries. The term "entrance requirement" is assumed to represent the work of a year with the ordinary time allotment for chemistry in the preparatory schools. The data have been obtained through direct correspondence with representatives of the institutions mentioned.

1. *Yale College.*—Does not require chemistry for entrance. Students may take an examination for advanced standing, but rarely do so.

2. *Harvard College.*—Those who have passed the entrance requirement take the same lectures as those who have had no chemistry, but they have special laboratory work and more advanced instruction in a special division. They are also allowed to take a first course in organic chemistry in the freshman year. Admission of such students to work in qualitative analysis has not proved successful. Those who present more chemistry than the entrance requirement are individually considered, but are rarely excused from college work on the basis of secondary school work.

3. *Cornell University.*—The entrance requirement is nearly the same as that of the College Entrance Examination Board, but the passing of this examination does not secure credit for introductory inorganic chemistry in the university. The student may take an examination for advanced standing if he desires.

4. *Columbia University.*—Those who pass the College Entrance Examination Board examination are admitted to a special course of lectures in chemistry, including a somewhat advanced treatment of the subject.

5. *Syracuse University.*—For one year of chemistry in a normal school credit is given for elementary chemistry in college, provided the student takes another course in chemistry and passes well. After one year of chemistry in a secondary school, pupils are allowed to take the regular examination in elementary chemistry, and if they pass, credit is given for that course. If chemistry is accepted for ad-

mission the student is admitted to second-year classes, but no credit is given for elementary chemistry.

6. *Washington and Lee University.*—Students from secondary schools with the equivalent of Remsen's "Briefer Course" are admitted to a course including physico-chemical topics and to qualitative analysis. If they do well, they are excused from the former at Christmas, and continue with analytical chemistry; otherwise they continue the course in inorganic chemistry through the year. A few students from selected schools are admitted at once to qualitative analysis, but no college credit is given.

7. *Washington and Jefferson University.*—Students from a few selected schools are given credit for the first year of chemistry in college, provided they take a later course in chemistry and attain a high pass record. Others are required to pass an examination before any credit is given. Chemistry is given in the sophomore year in this institution.

8. *Wellesley College.*—An advanced course is provided for those students who have had a year of chemistry. Smith's "College Chemistry" is used, and a somewhat exacting line of experiments is required. Some quantitative experiments, some volumetric analysis and some inorganic preparations are included.

9. *Chicago University.*—Students who have completed one year of chemistry in an accredited school are admitted to special courses and complete the work preparatory for qualitative analysis, or elementary organic chemistry, in about two thirds of the time required by beginners; that is, they complete two majors in chemistry in place of three. The work of these two majors is carefully adapted to utilize and clarify the knowledge already gained.

10. *University of Michigan.*—For a year of chemistry at an accredited school four hours of university credit are allowed (sixteen hours per semester is full credit). These students are admitted to a course somewhat less elementary than that given to beginners.

11. *University of Illinois.*—A full year of chemistry in a secondary school is accepted in place of one semester in the university, provided no more chemistry is taken (and provided chemistry is not offered for entrance). When the student continues in chemical subjects he is advised to take the regular course of lectures in chemistry, but spends less time in the laboratory.

12. *University of Wisconsin.*—Credit is given for entrance chemistry to the extent of one or two units out of fourteen. These students enter the same classes as the others, but have a slightly different laboratory course. In the course of two months they appear to be on about the same footing as those taking the subject anew.

13. *Lehigh University.*—Up to two years ago certain certificates were accepted from secondary schools but the results were so unsatisfactory that an examination has been substituted. Those who fail take elementary chemistry; those who pass are admitted to a course in theoretical chemistry.

14. *Sheffield Scientific School.*—If the student passes entrance chemistry, he is allowed to take an examination to pass off the elementary course in the scientific school, and if successful he is admitted to qualitative analysis. Very few students are thus admitted.

15. *Stevens Institute of Technology.*—Students pass an entrance examination like that of the College Entrance Examination Board, but the instructor finds that he can not make use of the earlier work,

and all students take a course in elementary chemistry.

16. *Worcester Polytechnic Institute.*—Earlier attempts to examine upon a limited portion of elementary chemistry with the purpose of definitely eliminating this from the college course were not successful. Note-books are now examined, and when these indicate a satisfactory course, the students are placed in separate divisions and given a different laboratory course. They attend the same courses of lectures as the beginners.

17. *Massachusetts Institute of Technology.*—Students who have satisfied the entrance elective requirement are admitted to a special class during the first term, and the lecture and class-room instruction, as well as the work in the laboratory, are designed to take advantage of the work already completed by the student in the preparatory school. The effort is made to introduce new lines of experimentation, as well as to reawaken interest in earlier work by encouraging the student to interpret the phenomena which he now studies in the light of his more extended experience, and with the aid of such additional concepts as have been introduced into the lectures and recitations. The two divisions of the class are united for the work of the second term.

Of these seventeen institutions one does not recognize chemistry for entrance, two make no specific provision for students who have had chemical instruction in the preparatory schools, three provide special laboratory instruction, but give no definite college credit, six provide special instruction in both lecture room and laboratory, but without giving college credit, while two give some college credit on certificate, and four excuse students from elementary college courses after special examination.

These institutions are sufficiently varied as to locality and type to justify the assertion that they represent the present practise on the part of thoughtful college teachers. That there is apparently much duplication of effort is at once evident, and that this must result in some loss of time, energy and enthusiasm hardly requires argument. Why, then, have we so long tolerated this apparent waste, and why do we not immediately take steps to avoid it? The answer seems to me to be this: It appears to be impossible to select any point in the chemical instruction received by the members of a college entering class at which they have such a sound understanding of the facts and principles already studied that this knowledge may safely be accepted as a foundation for further college instruction; or, if such a point may be selected, it lies so near to the beginning of the college course as to make a definite excuse from this small amount of work practically meaningless. There is, of course, a small proportion of students to whom this statement is not applicable, but it holds true of so large a proportion that it determines the character of the instruction which is given to all students who have had any previous chemical instruction. The situation does not appear to be appreciably better in institutions having a definite entrance requirement in chemistry than in others.

Some of the reasons for this state of affairs we will try to consider presently, but let us first look at the conditions as they confront the college teacher who has an earnest desire to enable his students to utilize every advantage which they have gained, remembering, however, that in these days it is not a question of individual but of class instruction, so far as the main features of a course are concerned. The college teacher or the teacher in a technical school will find among the members

of a single class students of each of the following types, with many variations:

Student A.—An intelligent, reasonably thoughtful pupil from a school where there are small classes, a well-arranged one-year course and a judicious, helpful teacher. Such a student is a source of constant pleasure, and much can be done for and with him.

Student B.—The chemical enthusiast who, during a course of one or two years' duration has been permitted, because of his enthusiasm, to work extra hours or to assist his teacher. He has won high praise and occasionally merits it, but too often the college teacher learns to dread the expenditure of energy and tact which is necessary to retain the good-will of such a student while bringing him to realize that a more profound knowledge than his own may be possible; yet, when the battle has been won, perhaps half of these men make excellent students.

Student C.—The student who has had two years of chemistry, in a course of ordinary excellence, under average conditions as to equipment and teaching. He feels, with some reason, that all this should count for a great deal, and no argument will wholly displace this notion. He works without interest, and generally badly, and is a heavy load to carry. You ask, Why not transfer him to the work of the higher years? We reply, Because experience has shown that he probably lacks adequate preparation for it, and will fail in it. The only practicable alternative lies in so arranging his laboratory practise that he shall have as large a measure of new work assigned him as it is possible to oversee without disproportionate attention on the part of the instructors.

Student D.—A student of moderate ability from an average school with a year of experience. His credentials are clear, but he has perhaps had little personal instruction and his knowledge is ill-arranged and vague, as to both fact and principle. He has no confidence in himself, and there is very little which is final in his preparatory work. His is one of the most difficult cases to provide for at the start, but often turns out well in the end.

Student E.—A student who has spent a year, or more rarely two years, under inadequate instruction, which has been worse than useless. An entrance examination may exclude him, but under other systems he becomes a troublesome factor in the complex problem and it may require some weeks to discover or be sure of his trouble. His place is with those students who take up the study of chemistry as beginners and his exclusion from the more advanced class is logical; but a transfer to elementary classes when these are provided is almost certain to breed discontent in the individual, and often disarranges other work of the term which, by that time, is well advanced.

But the confusion of interests does not end here! The types just referred to have been selected essentially along the lines of general efficiency of instruction and length of courses. It must further be recalled that even efficient teachers vary widely in their conceptions of the ground to be covered, and the college receives students who, during a single year of chemical instruction, have had the chief emphasis laid upon descriptive chemistry, others where it has been laid chiefly on "theoretical chemistry"; again others where the course is largely one of physics rather than chemistry; and, finally, where considerable qualitative analysis has been included even in this brief time.

The conditions appear, then, to be these, briefly stated: Experience indicates that the pupils who have had even two years of

instruction in secondary schools are, in general, not in a condition to take up work in chemistry which is more advanced than that of the first year in the college, and for students who have had but a single year there is at present so little that can be regarded as common knowledge that the present apparent duplication of work seems unavoidable. Regarding this duplication more will be said presently.

Let us next face the question, Why is it that secondary-school courses have failed, and, as it seems to me, are likely to fail, to serve as substitutes for any considerable amount of college instruction in chemistry? The reasons are far from simple, and they need some analysis. We may distinguish, I think, at once between certain factors which, since they are inherent in the nature of our science or in the period in the pupil's life in which the instruction is given, are common to all schools, and those elements in the situation which are the outcome of varying fitness on the part of the instructors.

Is it not true that chemistry itself presents some peculiar difficulties? It is often said that "physics is taught better in the secondary schools than chemistry." I am inclined to think that, as a general statement, it is essentially true. But might not the full truth be better stated in this form: "Physics is more effectively taught than chemistry in the secondary schools because physics is an easier science to teach"? It is true that chemical phenomena are plentifully at hand, and that our very life processes are dependent upon them; yet they are not recognized as such and are essentially unfamiliar. The teacher of chemical science, and the practitioner who seeks recognition for his achievements, are alike forced to realize that the tools which he employs, the working conditions which he establishes and the terms in which the results of his labors are to be expressed are unusual and strange and, because of this, more difficult of comprehension by his fellow men.

The beginner in chemistry is at a similar disadvantage as compared with the beginner in physics. In his work in physics the pupil handles, for example, the balance, the mirror, the pendulum or the battery, and he makes his measurements in units which are largely familiar to him; and the phenomena which he observes are not foreign to his daily life. On the other hand, the very test-tube and beaker to which the student of chemistry is immediately introduced are unaccustomed objects, the bottle of acid is still more so, and we often accentuate the situation by asking him to don breast-plate and armor for his personal protection, in the shape of aprons or rubber sleeves. While, on the one hand, the concepts and laws of physics may not be properly alluded to as "easy," yet it seems to me evident that they make less demands upon the intellect and the imagination than the fundamental principles of chemistry, if these principles are to mean more to the pupil than mere memorized statements.

With the growth of the holes in the pupil's clothing the strangeness of the beaker, test-tube and acid bottle lessens, to be sure, but he is coincidently introduced to increasingly complicated phenomena; he is asked to conceive of molecules, atoms, ions, even of electrons; he is asked to form some notion of valence, to construct chemical equations, and to "state all that they express"—a thing which you and I with our greater wisdom and experience may well hesitate to attempt. He must master the principles of stoichiometry, that branch of chemical science which seems to baffle the human intellect to a degree that never ceases to amaze even experienced

teachers. It may even happen that his course includes such concepts as those of chemical equilibrium, the mass law, or the phase rule which, in their relation to the proper subject matter of a secondary-school course, somehow remind one of the records of those early chemical processes found in the first chapter of Genesis in which it is quite incidentally stated that near the close of the fourth day the Lord created "the stars also." It is easier to forgive the ancient recorder for his lack of a due sense of proportion, than to excuse the twentieth-century instructor.

Keeping in mind, then, the newness of the chemical processes and chemical concepts, and the fact that the latter necessarily make considerable demands upon immature imaginations, may we not fairly ask whether it is actually reasonable to expect that a young boy or girl of fifteen to seventeen will gain a really clear insight into chemical science in one year; such an insight as will serve as a safe foundation for a chemical superstructure without further strengthening through review? I think I can hear teachers answering warmly in the affirmative. But, again, do they not have in mind the exceptional rather than the average pupil? It seems to me that experience indicates that the most that it is wise to attempt in the case of the large majority of pupils of the ages named is to broaden their horizon by teaching them to interpret common phenomena in the terms of chemistry, and with the aid of only the simplest fundamental principles to help in the understanding of those terms, leaving the meaning of the more abstract conceptions to be learned in a college course, or by later and more mature reading if the pupil is not destined for college, but has an inquiring mind. I believe that the disparity between the immaturity of mind of the pupil and the demands of the subject-matter assumed to be taught has been far too much ignored. I think this is the more true in these days when it seems evident that our educational system, through its multiplicity of subjects and the over-prominence of the baneful influence of the examination paper, tends to remove nearly all opportunity for concentrated or independent thought on the part of the pupil, or of originality in methods of instruction on the part of the teacher.

I believe, then, that even the competent teacher, with adequate equipment and the usual time allotment must find great difficulty in teaching chemistry to even the more receptive pupils at the secondary-school age so thoroughly as to permit the college to substitute it for any considerable part of the college course, at least under present conditions. For, let it be said with all humility, we college teachers too often made a sad mess of it even with the advantages as to maturity and environment, which we presumably possess.

The statement is sometimes made by college teachers that they would prefer to receive students without previous chemical experience, and the question may be raised whether or not it would be better to abandon entrance requirements in chemistry. I believe it is the opinion of the majority of college teachers, especially of those who have given the problem the most careful thought, that this would be very unfortunate. I should consider it so for at least two important reasons: first, because, while formal excuse from a definite portion of the college work is not yet generally practicable, the experience already acquired by the student can be made very helpful if judiciously utilized, and second, because it is mainly through increased cooperation between the schools and the colleges in an effort to secure better working conditions

for the teacher, and the adoption of a rational course of instruction in the secondary schools, which will take into account all of the pupils, rather than those alone who propose to enter college, that we may hope to attain better results.

It is noticeable in the statements quoted above regarding the present practise in the various institutions, that the state colleges are apparently giving a greater amount of definite credit for work in the secondary school than the others. This is frankly stated by some of the college teachers to be due to the closer organic connection of the state university with the general school system, and is admittedly done under slight pressure. On the other hand, these institutions have, through the system of school inspection on the part of the state universities, a more direct means of influencing instruction in the preparatory schools. The outlook for better conditions in the future is generally regarded as favorable.

Perhaps we may ask just here, What would these better conditions be like? It is probably fair to say that they would be such as to avoid duplication of work. Obviously repetition and duplication should be reduced to a minimum, and no one would welcome changes which tend to bring this about more than I. But I think it is possibly true that there is less actual duplication of work than is commonly supposed in those institutions in which the students who have had a year or more of chemical instruction are segregated in separate divisions. Let us take a concrete case by way of illustration. The pupil in the secondary school prepares chlorine, using salt, sulphuric acid and manganese dioxide, or hydrochloric acid and manganese dioxide. The time available rarely permits the use of any other method, and the chemical changes involved are sufficiently complex to present some little difficulty for their complete comprehension. Few pupils, as experience shows, really understand that this is a typical, and not an isolated or unique procedure, and the rôle played by the manganese dioxide is but vaguely grasped. It *is* true that such students are asked to again prepare chlorine from these materials in the college laboratory, but they are at the same time required to study the action upon hydrochloric acid of such agents as lead dioxide, barium dioxide, hydrogen dioxide, potassium permanganate or potassium dichromate, and to discuss the changes involved from the common point of view of the oxidation of the acid, and the proportion of actual duplication of work is really small. Similarly, in the study of the action of acids upon metals, while it is desirable to ask the student for the sake of completeness to repeat the familiar process for the preparation of hydrogen from zinc and sulphuric acid, this becomes a mere incident in the series of experiments and in the broader discussion of all phenomena observed, which may well go so far as to include the principles of solution tension, in the case of such students.

It is, apparently, work of this general character which many college teachers are offering to those who have had earlier chemical training. The laboratory work is, as we have seen, frequently accompanied by lecture demonstration and recitations of a corresponding grade, and while it does not, of course, appeal to the student as a step in advance, as would some other procedure which seemed to give a stamp of finality to his earlier studies, it may well be questioned whether it does not better foster his intellectual welfare than the more alluring plan could do. It should, however, be the purpose of the college teacher to keep closely in touch with the actual and probably increasing average

attainments of the pupils sent to him, in order that he may take all proper advantage of the instruction already given, and it is probably true that a larger number of institutions should offer such moderately advanced courses than is at present the case.

I propose next to refer briefly to one or two specific points at which it appears to me that the instruction in the secondary schools might be improved. I do this with much hesitation, for I realize that those very details or methods which perhaps fail to appeal to me may well be very dear to another, and I realize that I should be loath indeed to have the actual efficiency of my own instruction judged by certain alleged quotations on the part of some of my students, or even by the subsequent acts of many of them. A conspicuous instance of the failure of some of our hopes was afforded by a statement made by one of our students in a recent written test that "nitroglycerine is used as a lubricant."

A question which many find difficult to answer is this: How far, taking into account existing and not idealized conditions, is it just to regard note-books as an index of the efficiency of the instruction as given in a particular school, or college? I shall not be rash enough to undertake to answer this beyond expressing a conviction that while a note-book which is well kept and carefully corrected probably indicates careful, efficient teaching, a relatively poor note-book may represent more accurately an overburdened condition of the teacher, which prevents adequate inspection and correction, than actual inefficiency in instruction. For it is often true that much of apparent error in the records may have been actually corrected in conference or class-room. This does not, however, apply to some of the atrociously bad specimens which are occasionally met with, nor, on the other hand, does it ignore those note-books which are obviously not records of work done, but studiedly prepared exhibits, executed through connivance of teacher and pupil at the expense of a fundamental principle of all scientific work, rigid honesty.

Is it not true that too many teachers are contented to have their students perform more or less perfunctorily the magic "forty experiments" which are said by some one else to represent a suitable course, rather than to vitalize their instruction by devising ten, twenty-five, fifty-five or any other number of experiments of their own to illustrate the facts or principles which they themselves desire to fix in the pupils' minds, and to see that these are actually discerned. The busy, often overburdened teacher, will not always find time or energy to devise an entire course of instruction, but the introduction of even a limited amount of well-considered experiments or class-room instruction which represents the personal equation of the individual teacher does much to maintain enthusiasm for the teaching which is often reflected in the work of the pupils as well.

The deadening tendency of a mere following of a course of experiments laid down by others shows itself also in a disposition to regard each experiment as a thing apart, the nominal completion of which is a cause mainly for relief, is also reflected in many instances in the notes submitted, which are long and minutely descriptive of really insignificant details, but miss the real point of the experiment. This, in turn, comes from the fact that the pupil is not sufficiently informed why he is asked to perform the experiment at all, and in the strangeness of the work he naturally confuses the important and the unimportant. For example, he is often apparently left to think that a description of

"the apparatus used" is as essential when he pours silver nitrate solution from a bottle into a test-tube containing a halide solution, as when he is preparing nitric acid from saltpeter, and he elaborates his descriptions with the same fidelity in the former case as in the latter, with a very considerable aggregate loss of good energy on his part and that of his instructor. But that is not the worst of it, for he gains an idea that all experiments are to be treated with similar uniformity in other respects, even including his search for their hidden meanings. I do not, of course, advocate telling the student what is to happen and then asking him to say that it did occur, adding, possibly, the color of a precipitate; but I do believe that a great deal would be gained if nearly all experiments, or groups of experiments, were more carefully prefaced in the laboratory directions by a brief statement regarding the principles or the types of changes involved, and if, then, the student were encouraged to make his observations with reference to these statements and were required to show that he understands how the given experiment actually confirms the points in question. This would do much to avoid what is at present a wasteful expenditure of time, muscular energy and eyesight—all of which could be used to increase the pupil's experience, and it would partially, at least, eliminate the vague groping which results as those appalling scientific monstrosities which follow the words "I conclude" in the note-book of many a conscientious student. Have you ever recalled the bewilderment of your student days, when you had no idea what to look at among so many phenomena? Have you ever taken a half dozen experiments and candidly asked yourself what *you can legitimately conclude* from what has been performed? It is very much like trying to answer some of one's own well-sounding examination questions; a procedure which often causes them to lose their attractiveness.

Do we not, then, tend to lay too much stress upon mere performance of experiments, and devote too much time to the making and reading of descriptive notes which are often copies of the experiment manual, and too little time to helping the pupil, through judicious suggestions regarding the experiments and through questioning at the work-table and in the recitation room, to comprehend what it is all about, and the relation of a given experiment to others already performed?

In order that the perplexities of the college instructor may be brought more clearly to mind, and in order to illustrate certain types of note-books, I reproduce here a few pages from the books presented in connection with the entrance elective requirement of the Massachusetts Institute of Technol-

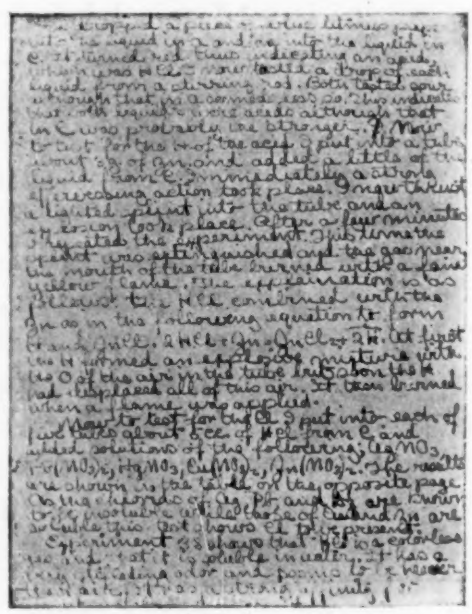

Fig. 1

ogy. The first (Fig. 1) is a representative of a rather small number of superior books. The observations are carefully recorded, the deductions are valid and well expressed and there is evidence (not shown in the cut) that the note-book had been inspected

and corrected. Under existing conditions as to numbers of pupils to be taught it is probably too much to expect that all will attain a standard which this note-book ap-

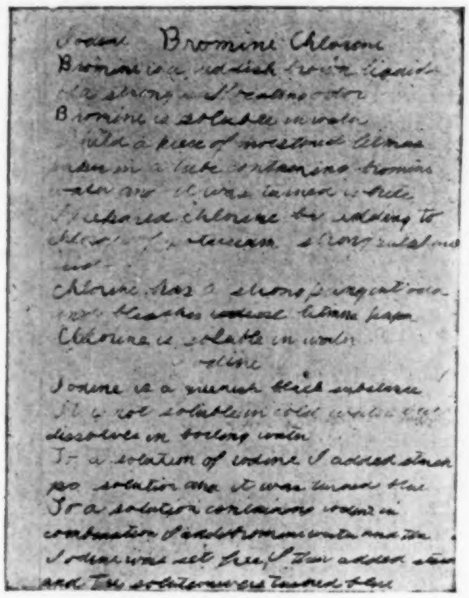

FIG. 2

pears to represent. To all appearances the records are original and the instruction efficient.

The pages reproduced in Figs. 2 and 3 are of a not uncommon type. The first

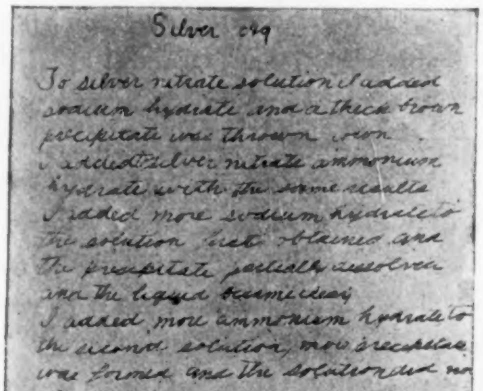

FIG. 3

leaves one in doubt as to what part of the work has been performed by the pupil, since the statements made regarding the physical properties could have been copied from a book, the records of experiments performed are distinctly wrong and, in the case of the alleged preparation of chlorine, would, if ever followed, lead more directly to a residence at a hospital than to any worthy scientific end. Fig. 3 shows a page which makes no pretense of being anything more than a mere record of a useless mixing of a few solutions, and moreover these records are also entirely wrong.

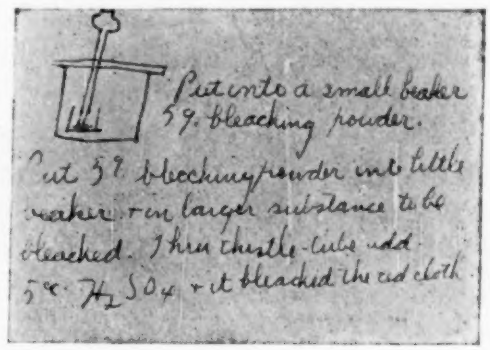

FIG. 4

The two pages just commented upon did not bear any evidence of inspection on the part of the teacher; that shown in Fig. 4 bore the stamped legend "approved," but a careful inspection leaves one in doubt as to what particular feature of the record warranted this, unless it may be the evidence of sympathy (?) on the part of the pupil with the tendency towards spelling reform.

These are not exceptional pages; they are representatives of many that pass under our inspection each year, and I ask you, with all sympathy for the teachers concerned, what evidence does any but the first give that one may safely omit a review of the ground supposed to be covered by this work in a college course which is primarily expected to furnish a safe foundation on which there is afterwards to be erected a very considerable superstructure of chemical knowledge? Are we not justified in our perplexities?

I should like also to appeal to the teachers in the preparatory schools to encourage

the pupils to better economize their laboratory time. Too many are allowed to placidly watch a crucible heat, or a solution boil, when other experiments might be in progress at the same time, and these habits are difficult to overcome. I should like to suggest, too, that some of the most promising pupils are often seriously harmed by allowing them to work too much by themselves, or by encouraging them to go beyond their depth in a particular line in which they appear to be specially interested, to the detriment of their fundamental work. Such pupils usually come to college with an exaggerated sense of their own attainments and it frequently requires long and tactful persuasion on the part of the college instructor before they can be reduced to reasonable humility.

On the other hand, I venture to plead that all proper encouragement be given to pupils to take advantage of such special privileges as the colleges offer. It is not an infrequent occurrence to find a pupil who tells us that he has been advised by his teacher to take the elementary course for beginners as one in which he will incur less risk of failure. Were the examination the goal of the course, there obviously would be little to criticize in this suggestion; its effect upon the student as an embryo scientist is seldom happy.

In conclusion let us ask, how can we make the work in chemistry in the various institutions more mutually helpful?

1. By a more extensive cooperation on the part of the colleges and technical schools in the way of separate courses for those who have taken chemistry before entrance, a closer study of the problem on the part of all, and a readiness to recognize improved conditions.

2. By an intelligent delimitation of the secondary-school course, so that it will only offer what the pupil can best assimilate at the age and in the environment in which he works. This is too large a topic for discussion in this connection, and it is sadly complicated by the necessity for furnishing a course which shall be alike useful for the pupil who expects to enjoy college opportunities and his less fortunate associate. I plead, as I have often done, for a course which is fundamentally descriptive in its character. I do not mean a mere catalogue of facts, but a course in which selected facts are taught for some specific reason, which is invariably explained to the pupil, and in which these facts are interpreted for him in terms of the simplest of the fundamental principles and concepts, so often repeated and constantly utilized that they may ultimately mean more than memorized paragraphs from what he may later remember only as "a book with a green cover." I think there can be no greater mistake than to suppose that such a course is a less worthy one than such as is often pointed to with pride as a "theoretical course," and no teacher should consider that it will demand less than his best efforts, supplemented by all his knowledge, to utilize the opportunities for helpful and thorough instruction which such a course affords. It is, of course, difficult to determine whether or by how much the instruction of the boy or girl destined for college should be differentiated from that of their fellow-students, but I venture to hope that a decision may yet be reached, through cooperation, which may permit us to select a limited field which shall be so well covered as not to necessitate repetition in college, and that this may be done without prejudice to the candidate or non-candidate for college credits. How soon this will come, or how large this field may be, I do not venture to predict.

3. By increasing the time alloted to chemistry in the secondary schools until it

is more nearly commensurate with the dignity and difficulty of the subject. Whether such increase should amount to one third, or some larger fraction of the present time allotment is a point which those actively concerned in the teaching can best determine. The increase in time should be asked for mainly in the interests of those who will not pursue the study of chemistry further, but it will also presumably hasten the time when a definite point of articulation with the college work, as just suggested, can be fixed.

Finally, there is the urgent need of decreasing the demands made upon the teacher of chemistry in the secondary school for duties other than those of chemical instruction, and also a critical need for relatively more instructors. I believe that a very large proportion of the unsatisfactory results now noticeable are due to the fact that in most of our schools it is not humanly possible for the teaching force to accomplish what should be expected of them, or to be at the desk of the pupil when he reasonably needs assistance. In some schools which have come under my observation the distribution of supplies must be attended to by the senior (or often the only) instructor, an operation which consumes a half hour or more. Probably no science demands for its understanding by the beginner more individual instruction in laboratory and classroom than chemistry, and the school authorities should realize this. When they do we shall have much cause for rejoicing, and much of the present groping and bewilderment on the part of the young student will give place to enjoyment in the study of a science which is really second to none in its attractiveness or value when pursued under favorable conditions.

It is a pleasure, in closing, to say that I feel that too much praise can hardly be given to the loyal, hard-working, intelligent and inspiring teachers who are accomplishing so much in behalf of our science in the training of the beginners. No thoughtful college teacher can fail to recognize the good work done in very many schools throughout the country, and while many feel that more definite recognition in the college curriculum can not wisely be given to this work at the present time, I am sure from the messages which have recently come to me from many colleagues in many institutions that there is an increasing appreciation of the fact that the way to better things lies through a sympathetic appreciation and study of our common problem and our common difficulties.[2]

If there be a determination, on the one hand, to undertake only so much as can be well taught and to give the largest practicable vitality to the instruction, and, on the other hand, a disposition to promptly recognize and utilize every bit of ground gained which offers a secure foundation for later work, a more satisfactory situa-

[2] In a discussion which followed the presentation of this and other papers on educational topics, a statement was made by a secondary school teacher of recognized standing to the effect that many such teachers had become indifferent to the opinions of college instructors, since it is "impossible to satisfy them any way." While I heartily sympathize with the thoughtful teacher who desires to teach his subject in his own way and with his own ideals in view, and deplore any attitude of the colleges, collectively or individually, which tends to interfere with this, it seems to me that the common cause of greater total efficiency in instruction can hardly be served by ignoring the opinions of the colleges, even if they are mistaken. May it not be true that the secondary school teachers lack some courage, or at least some persistence, in forcing their convictions upon the college teacher? They have the privilege of speaking from a fullness of experience with the young pupil which the college instructor usually lacks.

tion than that which exists at present can hardly fail to result, even though the degree of recognition of secondary school instruction may fall short of that which some desire.

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HIGH SCHOOL CHEMISTRY: THE CONTENT OF THE COURSE[1]

Every teacher in the high school of to-day finds himself in stimulating circumstances. He is obliged to question himself closely as to the part that his subject plays in the curriculum, for, at least in the large cities, the long-discussed change in the character of the high school is upon us. The reason for the change is found in a realization of the facts that in the past, high school education has been enormously wasteful; that eighty to ninety per cent. of our pupils do not complete the course; that only a small part of the remaining per cent. achieve the purpose for which the whole course has been framed, that of entering college. The evidence that the change has actually begun is found in the establishment of trade and vocational schools, in the frequent discussion of questions pertinent to these points, and in the statements of principals and superintendents that something must be done to stop the enormous educational waste; and in their declaration that the high school must meet real needs, must give the boy or girl the education that is best for him or her, as a member of the human group, with little reference to college entrance.

Among the changes that are coming from a recognition of these facts, we find the importance of science in the high school largely increased. The fact that it is science that has produced the great material advance of the past century makes it certain that in the further turning from formal to practical education, science will play a larger part. It is the purpose of this paper to inquire into the manner in which these changing conditions are reacting on the high school course in chemistry, and to discuss some of the considerations that are determining, or should determine, a new course of study. The speaker wishes also to discuss, in general, the problem of high school chemistry, presenting personal and perhaps even extreme points of view.

We may classify the various forces that are shaping the new course as external and internal. In the first class we find: (*a*) a lessening of the college influence, due to a realization of the necessity of educating for other purposes than college entrance; (*b*) a tendency to put chemistry earlier in the course and to give a second year of it; (*c*) what we may call the lay demand for practical education.

The lessened college influence will give to the body of secondary teachers not only greater freedom in the selection and arrangement of their material, but what is of even more importance, because it serves as a stimulus to their creative ability, a realization of the importance of their own great work and their responsibility for it. The lack of this kind of freedom is in part responsible for the condition that exists to-day when the high school, paying comparatively high salaries, can not get enough good men, while the college apparently has more than it needs at a smaller compensation. This is not the least of the evils that have resulted from the college domination of the high school. Others have often been pointed out and are well known. The course of study can never be adapted to the real needs of the high school so long as it is framed by the

[1] Presented at the second decennial celebration of Clark University, Worcester, Mass., September 16, 1909.

college, at the best a force operating at a distance, at the worst a power acting for needs it can not know. The college, as far as the high school was concerned, always had the idea of preparation, not growth, in mind. A thousand boys went through a course in chemistry whose nature was determined solely by the needs of the three or four who were to be trained to be expert chemists. It is often said at this point that the course which best prepares the pupil for advanced work is also best for every other boy. It is nearer the truth to say that the education which best meets the needs of the growing member of the human whole ought to be the best preparation for college.

Chemistry earlier in the course and perhaps a second year of it; the first of these conditions may bring dismay to many teachers; the second, delight to all, surely. Certainly some changes in the traditional course are necessary in teaching chemistry in the second year. On this point the speaker can refer to an experience covering nearly seven years. During all that time chemistry has been taught to some second-year students. At times fourth-year students and second-year students have been taking nearly the same course simultaneously in separate classes; at other times the two terms of students have been mixed in the same class. In both cases a certain degree of success with the second-year students has been obtained, even if we judge by no other standards than results of college entrance and state board examinations. Speaking for the moment from the standpoint of the college entrance syllabus, but little change is necessary to adapt the chemistry to second-year students. A less rigorous insistence on the philosophical development of the atomic and other hypotheses seems to be the most necessary item of change. In any case, as far as the ability of the student to comprehend is concerned, the difference between individuals is much greater than the difference between second- and fourth-year classes. The general average of work is considerably better in fourth-year classes, but this is explained largely by the dropping out of weak material.

To meet the demand for practical education, we find that there is a decided tendency to introduce into the high school a great deal more of chemical technology than there was in the older course. There are some who go so far as to say that the high school ought to give the pupil a means of earning his living; that chemistry should be taught so as to fit him for some direct employment in practical occupations. While admitting this as a possible ideal, the view implies such an extreme change in the character of the high school that it is not advisable to take it into consideration in the present discussion, except to admit that, given time, it would be possible to accomplish this result. Along with the demand for technical education, we find a tendency to fill the course with a great deal of matter that is associated with the home and every-day life. These two demands have come largely from without. They have done great good and have added much to the human interest of our science. We teachers are very prone to an academic point of view, and the stimulus has been a needed one. Yet with the good, there is some danger. There is a tendency in some quarters to emphasize the technological details of processes, to fill the discussion with technical terms, so that the pupils' talk bristles with tuyères and downcomers and the particular names of the many towers that find application in manufacturing chemistry. The chief evil of this kind of instruction is that it produces rather showy results, it seems to indicate more knowledge

than really exists. Moreover, a technical process of to-day is a very complicated thing. It is improved every year and we find to our discomfiture, on visiting the factory, that the process we have so carefully learned from the text-book differs in a hundred details from that actually employed.

The chemical interpretation of the ordinary phenomena of the household is a very interesting matter. Unfortunately many of these interpretations are very complex, others are unknown. Some are simple enough to be comprehended by a beginner, and certain food tests and the like can be taught so that the pupil can go through them in a more or less mechanical fashion. But surely these do not constitute a suitable vehicle for the transmission of that highly organized mass of knowledge and way of thinking which we know as chemistry. The intellectual and material advance that our science has brought to the world has not come from the knowledge of isolated test-tube reactions, but from the brilliant imaginings of the authors of its great hypotheses, from the realizations of its tremendous generalizations, from the perceptions of most deeply hidden relationships among the things that we call matter. If this that we teach our pupils is to bear the name of chemistry, it must give them at least a glimpse of these deeper things. Technological chemistry and household chemistry have a very proper place in the high-school course, but they should not be over emphasized. They afford the illustrative material which the good teacher will constantly use to give interest to his work by showing what good the science has brought to mankind. But a course composed almost wholly of such material, as has been proposed, would not be chemistry, and it would probably not be science. There would be an absence of principles, of relationships. A pupil might indeed learn that there exists a simple process for the manufacture of soda, but he would not share in any degree the kind of thinking that has made this and a thousand other processes possible. I hold that it is our chief duty to give him this kind of knowledge.

Coming then to the internal considerations which shall help shape our new course of study, we must inquire what high school chemistry should seek to accomplish for the pupil. One way of answering this question is by asking ourselves what it has done for us as individuals. We know that it has made us broader men and freer human beings, and it is fitting that we should seek to have our pupils attain in some degree this high end. Again, it is certain that one who has been through a good course in chemistry, who has learned the principles of chemical action, and comprehended the great laws that the science has revealed, looks upon the world about him in an altogether new way, so much so that with the increase in the general knowledge of science there is being produced a new type of world mind. Our pupils must be taught so that they shall share in this new world mind.

THE LABORATORY ASPECT OF THE COURSE

The course will continue to be based on experiment, the amount of laboratory work being limited only by the physical possibilities of the situation. The experiment will precede the class discussion in order that the pupil may conceive the things that he is talking about as realities. Chemical thinking can not go far without these definite conceptions. It requires images of real things, and it is this point of view that should determine the character of our laboratory work. There seems to be considerable difference of opinion, if not confusion, on this point.

There is the point of view which assumes that it is the purpose of the experiment to

prove the statement of the teacher or the text. Because there was so much that was bad in reliance upon authority in older types of education, it is felt that science must have none of this, but must accompany everything by rigorous proof. Following this method at its worst, the pupil is stimulated into a condition of perpetual doubt. He meets every statement with a but, and has rather the air of believing that some scientific charlatanry is being imposed on him. This is wrong; science does not have this attitude of perpetual doubt. It requires the most rigorous proof from discoveries of new things, but if each of us had demanded ocular demonstration at each step in our advancing knowledge, we should probably still be somewhere in the realm of descriptive inorganic chemistry. Moreover, it is a serious scientific mistake to let the pupil think that a single experiment performed under the ordinary condition of the beginner's laboratory proves much of anything. If it does, the speaker has seen many curious things proved in his time. Let us be frank: these experiments show at best the line of thought by which the proof is obtained. They illustrate the proof—they do not give it.

Nor does the theory that the pupil should, in the laboratory, rediscover the fundamental truths of the science, give us a right basis for experimental work. Followed to the extreme, this method soon reduces itself to an absurdity. Take, for example, the experiments of Lavoisier, which afford such an excellent starting point in the teaching of the subject. The pupil is given some metals and a balance, and is supposed, in an hour and a half, to rediscover what it took the best minds the world then possessed several centuries to accomplish. The fact the pupil's laboratory record, duly attested by the teacher, indicates that he independently accomplished this prodigious feat is a comment on the system. All that is done in this method at its best, is the arousing of the pupil's curiosity, which is later gratified by judicious suggestions at the proper moment from the teacher. There is no rediscovery; the line of thought has simply been retraced, and the big steps have been taken by the teacher. To be a discoverer you must be the author of your own curiosity. Another trouble with this method is that once committed to it the teacher is driven to curious round-about expedients to prevent the pupil's having knowledge in advance of the thing he is going to see. There are hundreds of instances where the pupil should have this knowledge in advance.

The speaker is more and more convinced that while the laboratory should to a certain extent seek to accomplish the things which the holders of two points of view consider desirable, its real purpose is to afford illustrative material, and by illustrative material he means that which will give concrete ideas—images—of things and processes. One might read hundreds of pages about chlorine, but if he had never seen it he would never know it. This is the great work of the laboratory method, to teach things and not literal symbols for them. We should seek this end, and let other considerations give way to it.

And we shall not neglect to exercise the pupil's scientific imagination. Chemical thinking requires this faculty. After he has been well grounded in the method of the laboratory, we shall want the pupil to learn to foresee chemical possibilities. The progress of the science has been by the working together of experiment and imagination, the one reacting upon the other and each suggesting in turn new steps in the advancing knowledge.

THE CLASS-ROOM ASPECT OF THE COURSE

It is no longer being framed exclusively

for the college entrance requirement; our course will not require us to cover so much material as it did formerly. Discussion of the rare elements and their compounds will give way to a more intensive study of those that show typical chemical actions, and establish the main lines of thought. We shall prefer to do this by reference to the things of the practical life where we can, but we will not go into the chemistry of foods, dyes, textiles and the like, knowing that this matter is far too complex for us to use in establishing the laws and relationships that are necessary for a comprehension of the science. We shall draw from every aspect of chemistry in our effort to establish the principles of chemical action. Our teaching may grow less descriptive and more dynamic. We may find it better to study types of chemical action than to study elements and compounds. As suggestion along this line, we might proceed, after reaching the definitions of chemical action, element and compound, to the general study of simple decompositions, using many experimental illustrations. We would bring in the ideas of stability and heat of formation. We would then proceed to direct combinations, simple replacements, and so on until finally the pupil would have a very good idea of the comparatively few types of chemical action. He would acquire incidentally a very practical descriptive knowledge.

Our course will necessarily continue to pay a large amount of attention to chemical theories, in order that we may have the means of seeing analogies and interpreting results. The mechanism of chemical changes is so far removed from direct observation by the senses that any attempt to comprehend these must be largely by aid of the imagination. The atomic theory has given us a splendid instrument for this purpose. We should retain it even if it had done nothing more than give us a system of chemical formulas, or made it possible to represent chemical actions by equations. Only one who has attempted to teach chemistry without the use of these symbols can fully appreciate what a tremendous aid they are. We shall therefore want to establish the atomic theory rationally, and to show how formulas are determined. This is perhaps the most difficult part of our work, but the fact that many pupils fail utterly to comprehend this matter is no ground for its omission from the course. There are many who succeed, and we must not forget that those who fail at least learn that such knowledge was acquired by human reasoning and patient experimenting. We should make our pupils feel that these theories are very practical things indeed, since it is largely by their aid that the science has advanced and brought material benefits to mankind.

We have in the past been given to considerable drill in certain types of chemical problems, largely because of the demands of college entrance examinations. There has been a good deal of mental gymnastics in the matter. These calculations should be taught in a less formal way; the laboratory is the best place to do it. Let the pupil calculate from the equations the quantities of substances he needs for his reaction, and then actually mix them in these proportions. Let him get practise in correcting gas volumes in the course of experiments involving simple gas measurements. Knowledge acquired in this way has a far greater staying quality than that obtained in formal class-room drill.

As we have already said, chemical technology will find a place in the course, but it must be taught by principle too. In the Solvay process, for example, it is more important that the pupil should get the idea of precipitation by differences in solubility than that he should know the mechanical details of the carbonating towers.

It is more important he should know that the process is only commercially profitable because the ammonia is recovered, thus getting hold of the principle of the utilization of by-products, than that he should know the factory terms for the machinery and operations. A good course in manufacturing equipment, in which different types of furnaces, towers and the like were grouped and compared might be of great practical and educational importance. But isolated bits of such information have no such value.

Our high-school chemistry might well include a treatment of more organic compounds than it has in the past. This knowledge can readily be acquired by reference to inorganic types. So many of the simpler derivatives of the hydrocarbons are things of every-day life that in order to include them we can afford to sacrifice some of the things of the traditional elementary course. The pupil needs, moreover, some intimation of the character and extent of the organic branch of the science.

In conclusion, the speaker feels that the best hope for the improvement of high school chemistry lies in discussions of the kind we are engaged in this morning. The experimental end of our work has been so new and interesting that much of our time has been spent on these matters. But the time is at hand when a reconsideration of the course as a whole in its general relations would be of benefit to the teaching of the elementary science.

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CHEMISTRY IN SECONDARY SCHOOLS[1]

IT is not necessary in a gathering such as this to recount the stages in the history of chemistry teaching in secondary schools —how, from the purely descriptive natural philosophy of the early college we finally essayed the teaching of chemistry and physics as sciences; how the miscellaneous encyclopedic instruction has been replaced by courses, designed, in these latter days, to develop power for the pupil rather than to impart knowledge.

The changes in content and method of formal secondary-school instruction have been brought about by the colleges; by advice, by supplying the teachers and most drastically, by the requirements for admission. While the bulk of the class might pass from the school and not be heard from again, the failure of a pupil to pass the college examination is quickly brought home to the teacher, so that the entrance examinations have become the standard of the school.

During the last fifteen years four syllabuses have been published which have decidedly affected the teaching of chemistry in schools; in 1894 that of the Committee of Ten, descriptive and general; in 1898 a Harvard syllabus, largely quantitative and scientific in method; in 1900, the syllabus of the College Entrance Examination Board, a plan for a course I hesitate to classify; in 1905, the last revision of the syllabus of the New York Department of Education, a historico-systematic course.

There is almost nothing in common to these four courses, and although the College Entrance Examination Board maintains and strengthens its hold upon the schools it has never, fortunately for the pupils, conducted its chemistry examination in accordance with its syllabus.

If we examine the texts to find what is being taught in high schools we find the chemistry text-books to be descriptive or theoretical; very few have successfully

[1] Presented at the second decennial celebration of Clark University, Worcester, Mass., September 16, 1909.

combined the two. The descriptive texts usually become encyclopedic, try to include all the elements, strange compounds, the latest processes and weird discoveries, often curtailing or entirely displacing those common things we are too liable to take for granted that every one knows. The theoretic texts are largely the product of college men. These tend to become too abstract and sacrifice the pupil to the subject. One elementary text of very wide use devotes two pages to a discussion of the action of bleaching powder, but does not state how it is used or for what goods.

If a subject is to be treated as a science many facts must be given and understood in order that the pupil may acquire a comprehensive idea of the subject. It is folly to expect thorough understanding of a part without a general knowledge of the whole. The high schools can not train chemists or engineers. Time and cost do not admit of such intensive science teaching, even if it is desirable. Such teaching should be left to the college.

If we take the pupils as we find them in our large city high schools they are not well informed and have little opportunity to be. They live in a complex environment. The city boy or girl is brought in contact with but few simple phenomena; a push of a button—a bell is rung; another push—a door is unlocked; another push—a light appears. The modern apartment is a complicated structure operated by buttons. If we look for chemical actions within this pupil's sphere we find them to be rather few, too familiar to hold the attention or too complicated to tempt analysis. He comes in contact with but few elements and but few pure compounds. Steel is to him a specially pure iron, zinc is the metal used in batteries, tin—used for cans, sulphur smells bad. He has often been told that soda water contains no soda. Soap is useful in cleaning, as it eats dirt as an acid "eats metals." A material involving electric means is necessarily superior.

The tendency to centralization in driving out small industrial establishments has narrowed the child's opportunities for observation. The shops of the blacksmith, carpenter and soap-maker where he learned the art of critical observation and learned some things not taught in school, have been withdrawn behind doors marked "no admission."

The classes of our large schools are mixed as to sex, race and ability. It is often said with pride that our urban population is cosmopolitan, but that the second generation from the emigrant is acquainted with American ways. Admitting that the second generation may be somewhat acquainted with American ways, we must also admit that the population of our large cities is becoming mongrel. The mongrel is never stable and is rarely successful. The psychology of the mongrel is analogous to that of the mob. Is it not then asking too much that children one or two generations from barbarity should be put through the same course and be expected to meet the same educational standards as the natives of Massachusetts?

The tendency of education at present is the development of *power*, of ability to reason, to think. We may, indeed, ask if the drill along this line has not been pushed so far at times as to neglect giving something to think about. The school, unlike the college, works by the clock, the work must be cut to fit the time, thus we often find a few facts or questions are presented in such a way that but one conclusion is possible. This is called inductive teaching—teaching to reason.

It makes the work easier for the teacher

if the work can be made to follow a mathematical model, so problems come to take an important place. The work becomes quantitative and is now held to develop thought, originality and logical reasoning. But the problem in elementary chemistry is usually of type form, and is not the teacher largely sponging on the power drilled into the pupil by the mathematics teacher? The English of the schools is criticized by college and business men alike. I believe a clear, concise exposition of phenomena in correct language will be of more benefit to the pupil than any number of problems in chemical arithmetic.

The pupils I have in mind are the ordinary ones in large schools, thirteen to sixteen years of age, girls and boys. Only a small percentage will go to college, some will go to business, some to be clerks, some home makers, some teachers. They have been herded in elementary schools, taught *at* in bulk. They are deficient in English and any correct notions of the activities of the world. It is the business of the high school to supplement the elementary school and by its specialization correct the errors of the grades and systematize the instruction. College preparation is only incidental.

A large amount of knowledge is not needed in practical life so much as the power to do things, but knowledge certainly increases power. While we must be able to do one thing well even a superficial knowledge of many things is not to be despised. Good judgment, ability to arrive at accurate conclusions from given data is most essential, but if we look closely a large part of what is commonly called reasoning is but rehearsing of formulæ. Good judgment can not be taught. So few of our pupils will ever be so situated that they need reason independently concerning chemical phenomena that it is scarcely justifiable to foist the time and cost of such instruction on the public.

Where and how can chemistry accomplish the most good in the school? If the object of education is to develop a youth most completely, to make a well-rounded individual, to make him feel an intelligent interest in the activities of the world, it is not necessary that each factor in such a total should be well rounded. A number of smooth, well-rounded sticks will make a very insecure bundle, but if some of the sticks are somewhat rough the bundle may not appear so elegant but it will be more firm. Chemistry touches every phase of human activity. It requires language for its expression, mathematics for its determination, physics for its operation. Its history is the history of the world.

It would be impossible to find a better subject than chemistry to bind together the school work, to systematically furnish splinters to make the bundle strong. The domestic science teacher, the biology teacher and the physics teacher give some splinters of information which they call chemistry and build their work upon this basis, usually indigestible definitions. A systematic course in elementary science should be placed in the first year of the high school, designed to impart that information of things and processes we might well expect every one to know. This might be followed later by a course more thorough.

We now expect our pupils to specialize as soon as they leave the elementary schools and to prepare for some life work. He or she knows nothing of human activities out in the everyday world, there is practically no place in the school curriculum where this is taught. We have trade schools, vocation schools, commercial schools, not to mention others all of which require him to specialize before showing

him any general plan from which to choose or guiding his choice.

The pupil who will receive no further school instruction can in a year be given a good knowledge, by a teacher with adequate equipment, of many of the facts of elementary chemistry relating to our daily life and its activities—a knowledge sufficient in most cases to excite a lasting interest in natural phenomena and to cause the student to seek explanation. There is a multitude of chemical facts which concern the boy who goes into the shop or office or behind the counter, and which he should know. The girl who will stop at home or teaches others' children is also concerned with chemical phenomena. chemical information which has been crowded out of her curriculum to make room for more cultured and less mussy subjects.

Adhering to traditional procedure, our science courses have become pseudotheoretical or pseudotechnical; it is time we had one systematically informational and practical. Facts are as important as explanations and should precede them. Such a course need not pretend completeness in any line. It might be comparative rather than critical. It would not attempt to rediscover or verify natural laws, but would aim to cultivate the powers of observation and of accuracy of description, to express ideas of phenomena in simple, direct English rather than to hide incoherent thought behind a big name or a slang expression.

In a first course in chemistry, atoms, molecules, ions and many other terms might be omitted altogether. They are but words, the modern idea of an atom is incomprehensible to one without a wide knowledge of chemistry. Theory should be eliminated as much as possible, making the course treat of facts, their sequence and relation to one another. Numerical problem solving should take but a small part in recitation work. No more can come out of an equation than we put into it. It can not develop originality.

Such a course for children of twelve to thirteen years would need simplicity in its treatment. Faraday's lectures to children are a model in this respect. Ostwald's "Conversations" show how some complicated things may be dealt with simply.

I would have such a course give information concerning natural phenomena and the work of man, show what is being done, and how, without technical detail.

I would give the pupil something to *know*. Facts that are worth knowing in and of themselves—facts that concern himself, his food, his clothing, his shelter and his work. Concerning the things he or she will meet in life, no matter whether the future be as a chemist, a bookkeeper or in the kitchen. The material is ample.

The subject might be systematized by its applications rather than the traditional order. Study topics rather than elements; study detergents, not soap; study bleaching rather than peroxide or bleaching powder. The development of the race through the stone, bronze and iron age has depended largely upon his chemical knowledge. Let us study the metals in their metallic aspects rather than according to the periodic table.

Foods, clothing, materials of utility and convenience or of commerce often can not be rationally treated by the present systems of our texts, but a suitable systematization might easily include these; what they are, how they are produced and what they do.

In its effects upon the pupil and school, we may be sure that pupils who have seen something of the general trend of the instruction through a systematic preliminary

course will feel more interest to continue study and will accomplish more and better work in later courses.

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THE AMERICAN MEDICAL ASSOCIATION[1]

THE St. Louis session of the American Medical Association was an unqualified success. From the scientific point of view, and from the effect in the promotion of a closer and more harmonious organization of the profession, as well as of social interest, little more could have been desired. The registration was a little over four thousand, a number exceeded only twice—at Boston and at Chicago.

In the scientific interest and in the earnestness and fulness of the discussions on the topics presented the section meetings equaled or surpassed those of any previous session. Every section had profitable meetings and the attendance in each was good. Especially notable were the symposiums in the Section on Preventive Medicine and Public Health on hookworm, pellagra and typhoid fever, and in the Section on Pathology and Physiology on cancer—subjects which, aside from their interest to the profession, have particular interest for the public, because of the widespread morbidity and mortality which they cause, especially in the instances of typhoid fever and cancer. Indeed, it is interesting to note the many points at which the papers throughout the whole program of this session touched the public directly in the matter of hygiene, sanitation and prevention. It is a reflection of the wide-spread interest of the public in what is being done in medicine. In many respects the Section on Preventive Medicine was the most interesting of the session. Cancer, with its frightful mortality and increasing prevalence, was probably the most prominent subject of the session, being considered in one or more of its aspects in almost every section, far outshadowing tuberculosis in this respect. In some of the other sections symposiums on diabetes, the infectious diseases and eclampsia, with the discussions, served to clear the atmosphere about many mooted questions. There were many other interesting features of the scientific program, but space forbids further mention of them here.

[1] From the *Journal* of the Association.

The meetings of the house of delegates were harmonious throughout. Each succeeding year the reference committees are doing more and more work, making it possible to investigate thoroughly all the various propositions that come before the house; and thus the house is able to accomplish much more, and to do the work in a deliberate, satisfactory manner. Of the important things done by the house of delegates, one was the creation of a new Section on Genito-urinary Diseases, as petitioned for by many members doing work in that line. Another was the creation of the Council on Health and Public Instruction, which is to have charge of the work formerly done by several overlapping committees, covering such matters as preventive medicine, medical legislation, economics, public instruction in medical, sanitary and hygienic questions, etc. The council will organize complete machinery to facilitate the attainment of these objects.

Any impression that there was the slightest lack of harmony in the organization was dispelled by the work of the house of delegates and by the spirit shown in the daily work; and any attempted disparagement of the aims and purposes of the American Medical Association was silenced by the splendid statement of them contained in the address of President Welch at the general meeting. That the public correctly understands these aims and endorses them was evinced in the admirable address of Governor Hadley and the other gentlemen who spoke at the general meeting.

THE ASTRONOMICAL OBSERVATORY OF DENISON UNIVERSITY

AT Denison University, Granville, Ohio, the new astronomical observatory, presented by Mr. Ambrose Swasey, of Cleveland, was opened

on June 15. In the afternoon an address on "The Contribution of Astronomy to General Culture" was given by Edwin B. Frost, of the Yerkes Observatory, and in the evening an illustrated lecture on "The Revelations of the Telescope" was delivered by John A. Brashear, of Pittsburgh.

The observatory is a very beautiful structure of white marble, and its interior finish is in excellent harmony with the elegant exterior. The principal instrument is a nine-inch telescope, with object-glass by the J. A. Brashear Company, with the latest style of mounting by Warner & Swasey, complete in every detail, and with a filar micrometer by the same firm, of which the donor is vice-president. A fine four-inch combined transit and zenith-telescope is also provided, together with a chronograph, all by the same makers. The equipment also includes two Riefler clocks, for mean and for sidereal time, and a sidereal clock for the dome. The observatory is very well situated upon a high ridge commanding the horizon, and is admirably adapted for its purpose, principally educational, but the equipment is also sufficient for useful contributions to research.

SCIENTIFIC NOTES AND NEWS

The Paris Academy of Sciences has conferred the Janssen Prize, consisting of a gold medal, on Director W. W. Campbell, of the Lick Observatory, University of California.

Dr. John Benjamin Murphy, professor of surgery in Northwestern University, has been elected president of the American Medical Association, for the meeting to be held next year at Los Angeles.

The University of Pittsburgh has conferred the doctorate of science on Professor H. L. Fairchild, professor of geology in the University of Rochester.

Dr. Oscar Bolza, professor of mathematics in the University of Chicago since its establishment eighteen years ago, has been made non-resident professor, and will live in Freiburg, Germany. He will receive his regular salary.

We learn from the *Journal* of the American Medical Association that a bronze relief portrait of Dr. William Osler has been placed in Osler Hall of the Medical and Chirurgical Faculty, Baltimore. It is by F. C. V. de Vernon, a French sculptor, and is an enlargement of a small one made in 1903 by the same artist and now in the Johns Hopkins Medical Library. It will be placed by the side of the Osler portrait by Corner on the north wall, and on the other side will be hung the Welch medallion.

After nearly continuous service of nine years in the American Museum of Natural History, Director Hermon C. Bumpus has been granted a vacation by the trustees, beginning June 15. Dr. Charles H. Townsend, director of the New York Aquarium, has been released from his duties for the same period and has been appointed acting director of the museum during the absence of Director Bumpus, which will probably extend to December 15, 1910. Professor Raymond C. Osburn, Ph.D. (Columbia), of the Biological Department of Barnard College, has been recalled from Naples to take charge of the aquarium, during the same period, under Director Townsend's general supervision. It is the intention of the Zoological Society to make Professor Osburn a permanent member of the aquarium staff.

Dr. Harvey W. Cushing, of the Johns Hopkins University, has been appointed chief of the surgical staff of the new Peter Bent Brigham Hospital at Cambridge, Mass. The hospital, which is the teaching hospital of the Harvard Medical School, will not be completed until about 1912. The fund has been accumulating for about twenty-five years and the original bequest of $1,800,000 has grown to about $8,000,000.

Professor H. A. Edson, of the University of Vermont, has resigned, to accept a position in the Bureau of Plant Industry, Washington, D. C.

Dr. Theodore Whittelsey has resigned as associate professor of chemistry in Northwestern University to become chief chemist of the

Rubber Regenerating Co. His address is Mishawaka, Ind.

DR. CHAS. W. HARGITT, professor of zoology in Syracuse University and director of the zoological laboratories, has been granted leave of absence for the coming year, and will devote his attention to research at several American and European laboratories.

PROFESSOR ROBERT H. RICHARDS, of the Massachusetts Institute of Technology, left on June 10 for summer school work with his mining students. He was accompanied by Professor Bugbee and Instructor Hayward. The party go to Buffalo, and from there take an ore steamer to Duluth, where they will see the ore docks. They expect to visit the Michigan copper region at Keweenaw Point, the nickel mines at Sudbury, Ontario, and the silver mines at Cobalt, Ontario.

THE collection of fresh-water sponges of the U. S. National Museum is now being critically examined by Dr. Nelson Annandale, superintendent of the Indian Museum in Calcutta, an authority on this subject.

M. DARBOUX, permanent secretary of the Paris Academy of Sciences, has been elected president of the Société de secours des Amis des Sciences.

PROFESSOR J. C. EWART, F.R.S., of Edinburgh, will give a course of lectures on the principles of breeding, at the Graduate School of Agriculture to be held at Ames, Ia., in July.

A BUST of Pasteur was unveiled on June 5 in the garden of the Ecole Normale Supérieure, Paris, where was his first laboratory and where he taught for thirty-seven years.

IN memory of the late Dr. Howard T. Ricketts, of the University of Chicago, who recently died in Mexico of typhus fever while investigating the disease, there has been established in Rush Medical College, of the university, a prize of the value of $25 to be awarded annually to the student presenting the best thesis embodying the results of original investigation on some topic relating to dermatology. The prize will be known as the "Howard T. Ricketts Prize."

DR. WILLIAM HENRY SEAMAN, examiner in the U. S. Patent Office and professor of chemistry in Howard University, died on June 12, at the age of seventy-three years.

THERE will be a New York State Civil Service Examination on June 25, for the position of civil engineer, at a salary of $2,224, and of chemist in the Department of Agriculture, at a salary of $900 to $1,200.

ELABORATE plans for the enlargement of the New York Aquarium are now being prepared by the Zoological Society, under the supervision of Director Townsend, by Mr. J. Stewart Barney, architect. The plans involve greatly improved architectural effect and will treble the present capacity of the aquarium. The institution is by far the most popular of its kind in the world. The attendance, under the administration of the Zoological Society, has increased very rapidly. This year it will probably equal, if not exceed, four and a half millions.

PLANS for the extension of the American Museum of Natural History are now being prepared by the trustees, and designs for the new west entrance pavilion and transept on Ninth Avenue will soon be submitted to the commissioner of parks. The committee on building and plans is also at work upon designs for the completion of the entire south half of the great museum of the future. The present building, erected between 1874 and 1908, includes eight units, that is, the south transept (the original building), the south entrance pavilion (the second building), three façade wings (two on the south and one on the west) and two corner pavilions, completing the south façade. The plans now in preparation contemplate the addition of six units more, which will complete the central hall and east and west transepts, the east entrance pavilion and the southeast façade.

WE learn from *Nature* that the valuable collections of native African art made by Mr. E. Torday in the southern Belgian Congo are now being classified and arranged by the authorities of the British Museum. The most

remarkable specimens in the collection are the wooden portrait statues of past rulers, which throw a new light on savage art in Africa. Next in importance are a splendid carved throne of the paramount chiefs, wooden caskets and cups, and specimens of remarkable textiles resembling velvet, made from the fiber of the upper skin of the palm leaf (*raphia*). This collection was made before the almost complete disappearance of native art work due to the importation of cheap European productions.

Courses in wood technology and the mechanical engineering of wood manufacturing plants are to be added to the curriculum of the University of Wisconsin for the coming year, the college of engineering cooperating with the new U. S. forest products laboratory in the instruction. The courses are to be primarily of a technical nature, arranged especially to meet the needs of students in the mechanical and chemical engineering courses who wish to prepare themselves for positions in the wood manufacturing industries. Three phases of the forest utilization problem are to be dealt with in these courses, including a study of the physical and chemical properties of wood, of the utilization of such wood products as are now wasted and the preservation of timber, and of engineering operations of manufacturing and preservative processes. Four courses in wood technology, including work in wood distillation, wood preservation, the chemical constituents of wood, and the physical properties of wood, are to be given by various members of the staff of twenty government experts at the laboratory. In addition there are to be lectures and demonstrations of the different operations in logging and wood manufacturing machinery, at the college of engineering, by Professor Robert McArdle Keown, of the department of machine design. In the course on the properties of wood, which will be given the first semester, the elementary structure of wood of various species will be studied, and the relation of its physical properties and its uses in the arts and industries. Lectures and demonstrations will also be given regarding methods of testing and conditioning wood. The course in constituents and fibers of wood, to be given the same semester, will deal with the chemical construction, lignoceric materials and fibers with their bearing on industrial and art uses of wood. The utilization of the waste in the lumber industry will be the special aim of the study of the principles, processes and products of hardwood and softwood distillation in the course in wood distillation to be given the second semester. The work in wood preservation will cover the structure and properties of different kinds of timber as regards their resistance to destructive agencies and conditions of deterioration. Both surface applications and antiseptic impregnation will be tested in the study of preservative processes, when the theory and effect of pressure in these treatments will also be considered.

UNIVERSITY AND EDUCATIONAL NEWS

Horace Russell, '65, president of the Dartmouth Alumni Association, has made a conditional gift of $10,000 to Dartmouth College toward an endowment fund to be used for the early increase of salaries of full professors, provided that additional sums can be raised to make the amount $100,000.

At the commencement exercises of the University of Pittsburgh, on June 15, a School of Engineering was dedicated, the principal address being made by E. K. Morse, president of the Engineers Society of Western Pennsylvania. At the same time the cornerstone of the building for the School of Medicine was laid, an address being given by Dr. James Ewing, of the Cornell Medical School.

At Stanford University Dr. Albert C. Crawford, of the Bureau of Animal Industry, has been appointed professor of pharmacology, and Dr. Hans Zinsser, of Columbia University, has been appointed associate professor in charge of bacteriology.

At the University of Illinois Mr. Frank C. Becht, of the University of Chicago, has been appointed acting head of the department of physiology in place of Dr. J. H. McClellan, who resigns to complete his medical studies.

DR. WALTER M. MITCHELL, of Philadelphia, has been appointed assistant professor of astronomy in the University of Michigan.

PROFESSOR L. S. GRISWOLD has resigned the chair of geology at the Missouri School of Mines, to give his entire time to consulting work. Professor Guy Henry Cox, formerly assistant professor of mineralogy and petrography, has been placed in charge of the department of geology and mineralogy. Mr. J. W. Eggleston has been appointed assistant professor of geology and mineralogy. He is a graduate of Amherst and of Harvard and has taught geology and mineralogy in the Colorado School of Mines and Harvard University.

THE following changes occur this year in the biological department of the North Carolina College of Agricultural and Mechanical Arts and Experiment Station. Mr. P. L. Gainey, assistant soil bacteriologist, resigns to accept a fellowship in the Shaw School of Botany. Mr. B. B. Higgins, assistant botanist, resigns to accept the position as assistant in Cornell University. Mr. T. B. Stansel is appointed as assistant in soil bacteriology (experiment station). Mr. Warren C. Norton is appointed as assistant in botany (college).

DR. LAWRENCE I. HEWES has been appointed assistant professor of mathematics at Whitman College.

MAURICE L. DOLT, instructor in industrial chemistry at Lehigh University, has been appointed assistant professor at the University of North Dakota.

MR. J. W. MAVOR, A.M. (Harvard), has been appointed instructor of zoology at Syracuse University.

DR. L. ASCHOFF, professor of pathology at Freiburg, has been called to Würzburg.

DISCUSSION AND CORRESPONDENCE

WATER VAPOR ON MARS

TO THE EDITOR OF SCIENCE: I venture to hope that you will regard the following communications as of interest to your readers.

C. G. ABBOT

ASTROPHYSICAL OBSERVATORY,
SMITHSONIAN INSTITUTION

LOWELL OBSERVATORY
SUPPLEMENT TO BULLETIN NO. 43

Quotation from C. G. Abbot, "A Shelter for Observers on Mount Whitney," Smithsonian Miscellaneous Collections, Quarterly Issue, Vol. 5, Part 4 (p. 506): "The observations of Director Campbell on the spectrum of Mars were entirely conclusive in showing that water vapor, if present at all in the atmosphere of Mars, is in less quantity than is contained in the extremely rare and dry part of the earth's atmosphere which is above Mount Whitney. In fact, no evidence at all of water-vapor on Mars was detected by Campbell."

. . . .

"Unfortunately, both Director Campbell and myself were on Mount Whitney during unusually unfavorable weather, for the whole southwest, including northern Mexico, was just at that time visited by floods of rain and cloudy weather. Such a condition would not probably be met with at that season one year in ten."

This admission speaks for itself. The excessive moisture must have pervaded the air generally to the masking of moisture on Mars. Even ordinarily summer is the most unfavorable time for getting any results, because the earth's moisture is then at a maximum.

SMITHSONIAN INSTITUTION
WASHINGTON, D. C.,
March 24, 1910.

Dear Sir: I have read Lowell Observatory Supplement to Bulletin No. 43. The supplement is unsigned and I do not know but it may have escaped your endorsement. I wish its author might have added in fairness the following facts given in Lick Observatory Bulletin No. 169, viz., Professor Campbell made spectrograms No. 1 and No. 2 on September 1, between $10^h 30^m$ and 15^h Pac. St. time. Of spectrogram No. 1 he says, "Little *a* shows plainly but very faintly in the Martian and both lunar spectra; less intensely than on No. 3 and more strongly than on No. 2; essentially equal in *Mars* and moon, and certainly not perceptibly stronger in *Mars* than in the moon." Of spectrogram No. 2, he says, "In the Martian spectrum *a* is difficult to see; if we were examining this Martian spectrum as an unknown spectrum, *we should almost certainly pass over the a band without suspecting its existence.*" Professor McAdie's sling psychometer was read on Mt. Whitney at $9^h 00^m$, $11^h 30^m$, $12^h 30^m$ and

$15^h\ 15^m$, Pac. St. time, on the night of September 1, 1909, and after the first observation the relative humidity was found not to exceed 4 per cent., the vapor tension not to exceed 0.15 millimeter at any of these readings.

My statement quoted in Lowell Observatory Supplement refers to the weather in general during our stay on Mt. Whitney, but referring to the weather on September 1 and 2, Professor Campbell states: "No clouds were visible in any part of the sky on either night. There had been a few clouds in the afternoons, but these cleared away completely at sunset. There were no clouds in the forenoon of September 3. We can not doubt the evidence of the clouds and the instruments that considerable moisture existed in the afternoons and early evenings, and that later in the evenings the vapor contents of the air were reduced to a remarkably low quantity."

I was present, and saw all the spectra, and can confirm Professor Campbell's description of them, and also his statement of the apparent condition of the sky during his observations. I also verified the excellence of definition of his spectroscope. If, as stated in the Lowell Observatory Supplement above referred to, "The excessive moisture must have pervaded the air generally to the masking of moisture on Mars," it could not, in my judgment, have failed to have produced a little *a* band of more noticeable strength both for Mars and the moon in spectrograms No. 1 and No. 2.

As of course you would not wish me to be placed by a bulletin of the Lowell Observatory in what I regard as a false light, I venture to hope you will do me the great favor to publish this letter completely.

By authority of the secretary:

Very respectfully yours,

C. G. ABBOT,

Director, Astrophysical Observatory

Director Percival Lowell,
Lowell Observatory,
Flagstaff, Arizona.

53 STATE STREET, BOSTON,
16 May, 1910.

Dear Sir: On my return from Europe to-day I find your note of March the twenty-fourth.

I am very sorry that you should feel hurt by a quotation of your own words, nor does it seem to me that your letter changes them in the least, and as to publishing the letters it receives, this is never done by the observatory.

Believe me to be,

Yours truly,

PERCIVAL LOWELL,

Director

Professor C. G. Abbot,
Director, Astrophysical Observatory,
Washington, D. C.

BACTERIA IN THE TROPICS

TO THE EDITOR OF SCIENCE: Allow me to correct a statement made on page 618 in no. 799 of SCIENCE. It reads: "As a matter of fact, the ordinary bacteria of northern latitudes do not flourish in the tropics."

During the summers of 1907 and 1909 I had ample occasion, as physiologist of the U. S. Experiment Station in Mayaguez, Porto Rico, to examine soils in this tropical island. I found that the most common soil microbes of the north occur also there. *Bacillus mycoides* takes here as there the most prominent position, then follows *Bacillus subtilis* and *Bacillus butyricus* (*Clostridium*) and then *B. fluorescens liquefaciens*. *Azotobacter* is found everywhere on the surface in great abundance. A superabundance of microbes in these tropical soils is checked by a very rich infusorial life. Infusoria, Flagellata and Amœbæ devour continuously great numbers of microbes. The nitrogen content of the superficial soil-layers is doubtless due to a considerable extent to the dead and living bodies of these low animals.

OSCAR LOEW

QUOTATIONS

THE SALARIES OF PROFESSORS

WHILE the universities of the land are receiving the most munificent gifts, while millions are devoted to the construction of marble halls and ivory towers, the wives of the college professors are trying to make both ends meet on their husbands' average salary of $2,500 a year. The size of some professors' families fails to support the theory of race suicide, but their stipends for training the youth of this great and wealthy country afford a pretty clear demonstration of the be-

ginnings of race homicide among the more cultivated members of the race. College professors must be presentable socially and as befits their learned station. They have not the means to rear their families.

If the plight of the professors is evil, that of the assistant professors is worse. Consultation of Bradstreet's tables shows that the cost of living has increased 50 per cent. during the period in which the assistant professor must serve before being promoted. The young men who choose a career in a university must, of course, and gladly do, abandon expectation of riches. But they should be permitted to live, not merely to exist, on a wage that is exceeded by the bricklayer's. After a general and specific investigation Professor Guido H. Marx, of Stanford University, recently reported in SCIENCE that assistant professors have found their salaries inadequate to support them comfortably as celibates, and many are seriously debating whether to resign their positions.

There is something unsound in university administration when the faculties are so ill-paid. Possibly competition with the state universities, which are steadily voting percentage increases of salary to their faculties, will stir the majority of privately endowed institutions to action. But their trustees have been too long asleep.—N. Y. *Times*.

SCIENTIFIC BOOKS

National Antarctic Expedition, 1901–1904. Natural History, Vol. V. London, British Museum, 1910. Seal Embryos, by Dr. H. W. MARRETT-TIMS. 21 pp., 2 pl. Tunicata, by Professor W. A. HERDMAN. 26 pp., 7 pl. Isopoda, by T. V. HODSON. 77 pp., 10 pl. Nemertinea, by Professor L. JOUBIN. 5 pp., 1 pl. Medusæ, by E. T. BROWNE. 62 pp., 7 pl. Lichenes, by Dr. O. V. DARBISHIRE. 11 pp., 1 pl., 4to.

The fifth volume of the reports on the Natural History of Captain Scott's expedition to the Antarctic edited by Mr. Jeffrey Bell has now appeared and the preface states that another volume will probably conclude this series of reports which has contained so much of value and so many additions to our knowledge of the Antarctic region.

The seal embryos all belonged to Weddell's seal and from the data accompanying them it seems that the period of gestation is about nine months, the young being born in October or November. They are covered at birth with a coating of hair which is shed during the first month. After the second coat appears the young seal may take to the water, though it is not weaned until some time later. The vibrissæ precede the body hair in appearance and were distinctly visible in an embryo four inches long. In a very early embryo what is regarded as a trace of an external ear was detected. The examination of the muscular system seemed to lend some additional support to Mivart's suggestion of a Lutrine origin for the Phocidæ.

The collection of Tunicata contained twenty-two species; excluding the pelagic forms there are thirty-three specimens belonging to fourteen species.

The Antarctic tunicate fauna is characterized by the abundance and large size of the individuals of a comparatively few species. Our knowledge of the fauna is still too limited to allow of a critical comparison with that of the Arctic, but a certain similarity of families and genera is noticeable. The strictly Antarctic region, south of latitude 60° S. has already furnished some fifty species of Tunicata, of which Professor Herdman gives a list. Ten new species are described, of which one is probably the largest *Styela* known.

No less than twenty-five species of isopods were captured. Remarkable sexual variation was noted among the Arcturidæ. An interesting feature, first pointed out by Miss Richardson, is the presence of long peduncles supporting the eyes; these have now been observed in seven Antarctic species. Mr. Hodson gives a list of the known isopods of the Antarctic region of which twenty-nine out of one hundred and eleven are strictly Antarctic, seven are also found in the Arctic regions, and the remainder belong to the subantarctic region.

The recent Antarctic explorations have produced a fair number of new Medusæ, many of which have well-marked and interesting specific characters, but there are only about three new genera. Probably, according to Dr. Browne, none of them will remain peculiar to the Antarctic when the ocean has been more thoroughly explored. The littoral Hydromedusæ of the Antarctic have not yet been found in the Magellanic, South Australian and New Zealand areas; it looks as if they belong to an ancient stock which has long been isolated from the rest of the world by the Great Southern Ocean. As evolution is proceeding more slowly in cold than in warm regions, the characters of an Antarctic medusa should be more primitive than those from a warmer sea. Dr. Browne gives comparisons which in a number of cases seem to sustain this view. Some very large scyphomedusæ are reported, including a *Diplulmaris* with arms twelve feet in length.

The lichen material brought back by the expedition included some twenty-five species and there are recorded from the Antarctic continent and closely adjacent islands some eighty-eight lichens. Of these thirty-eight are confined to the region between 60° and 78° south latitude, as far as known. The southern lichens do not present any new genera and occur in small quantities contrasting with the abundance found in the Arctic regions. Four species were found on the peaks of the Antarctic volcanoes, Mts. Erebus and Terror, and of these three are also inhabitants of the Arctic regions. That any indigenous organized object whatever can exist on these gloomy volcanic peaks covered with and rising out of eternal ice and snow, seems almost miraculous!

The plates of this volume are of the usual high quality, and the whole character of the work is such as would be expected from the authorities of the British Museum.

WM. H. DALL

Catalogue of the Lepidoptera Phalænæ in the British Museum. Vol. IX., Noctuidæ, 1910.

The present volume completes the account of the subfamily Acronyctinæ of the Noctuidæ. It contains 725 species in 185 genera, showing a total for the subfamily of 2,288 species in 385 genera. The volumes of this series are appearing with gratifying rapidity. We have only recently noticed the publication of volume VIII. The present volume is on a par with its predecessors in general plan and execution. The table of genera for the subfamily is again repeated with final additions and corrections and will now become fully available.

HARRISON G. DYAR

U. S. NATIONAL MUSEUM,
WASHINGTON, D. C.

SPECIAL ARTICLES

ON THE SPECTRUM OF MARS AS PHOTOGRAPHED WITH HIGH DISPERSION [1]

LET us recall that the solar spectrum, as viewed by terrestrial observers, is composite. Photospheric light, in passing out through the gases and vapors of the sun's atmosphere, is selectively absorbed, with the result that many thousands of lines are introduced into the spectrum. The transmitted light passes down through the earth's atmosphere to the observer, and the absorption by water vapor and oxygen in the terrestrial atmosphere introduces many hundreds of additional lines, at definite points in the yellow, orange and red regions. The observed spectrum of the sun is in reality the spectrum of the sun plus the spectrum of the earth. The spectrum of the moon, so far as our present problem is concerned, is simply this sun-earth spectrum.

The light from Mars is photospheric light, which passes out through the sun's atmosphere, thence down through the atmosphere of Mars to the planet's crust, where a certain proportion is reflected out through the Martian atmosphere, and thence down through the earth's atmosphere to the observer. The so-called spectrum of Mars is in reality the sun's spectrum plus Mars's spectrum plus the earth's spectrum.[2] Any water vapor and

[1] Read at the April, 1910, meeting of the National Academy of Sciences.

[2] A little of the light would be reflected from the atmospheric strata of various heights without

oxygen in the Martian atmosphere should introduce the same absorption lines which are introduced by the earth's atmosphere in the sun-earth spectrum.

If the distance between Mars and the earth is not changing rapidly, the water vapor and oxygen lines from Mars and the lines from the earth will coincide. When this condition of coincidence exists, it is clearly a difficult problem to detect moderate quantities of water vapor and oxygen in the Martian atmosphere, for the evidence of Martian absorption will be overwhelmed by the absorption of the richly laden terrestrial atmosphere, especially if the observer be near sea level. To hope for success, the observations should be made from a high-altitude station, at times when the overlying air strata carry a minimum of water vapor, and when the planet is as near the zenith as practicable; observing the lunar spectrum, under identical conditions, for comparison.

Because of the faintness of the Martian and lunar spectra, it has been found that we are limited to low dispersion in visual observations: and that when the distance between the two planets is constant or nearly so, low dispersion offers a more sensitive method than high dispersion, even when photography is employed.

Complying with the conditions in the two preceding paragraphs, the writers photographed the spectra of Mars and the moon last September, from the summit of Mt. Whitney. The conclusion drawn from that investigation was, in brief, that the quantity of any water vapor then existing in the equatorial atmosphere of Mars was too small to be detected by the spectrographic methods available. This does not mean that the Martian atmosphere was carrying no water vapor, but only that the quantity must have been very small.

At times other than those when Mars is near opposition, the earth and Mars are relatively approaching or receding from one another. Their relative velocity at quadrature may amount to 20 km., more or less, per second, depending upon the concurrence of favorable circumstances.

When Mr. Campbell was photographing the spectrum of Mars, in December, 1896, with a Rowland grating, fourth order,[3] 568 lines per mm. (14,438 per inch), he realized that the Doppler-Fizeau principle offers great advantages, in theory, for solving the problem of the Martian atmosphere, for on photographs of the spectrum, made near quadrature, with sufficiently high dispersion, the Martian absorption lines and the terrestrial absorption lines should be separated. At that time (thirteen years ago) the method could not succeed, for all the prominent water vapor and oxygen lines are in the region on the red side of λ 5875, and the photographic dry plates then available were not sufficiently sensitive to record this region. Even in the fairly sensitive region λ 5700–λ5800 the grating spectrograms of Mars were underexposed. The successes of recent years in sensitizing dry plates to yellow, orange and red light have encouraged the present effort to apply the method.

A spectrograph, designed by Mr. Campbell to meet the requirements of the problem and used in connection with the 36-inch refractor, contains an excellent Michelson five-inch plane grating (15,000 lines per inch) which gives a brilliant spectrum in the second order on one side, and this was utilized. The wooden mounting of the spectrograph was designed at all points to resist differential flexure during the intervals of exposure to the planet and to the moon. The instrument was adjusted, the observations were secured, and the measures and reductions of the spectrograms were all made by Mr. Albrecht.

It was planned to secure observations of Mars and the moon on or near January 17, 1910, as the planet was in quadrature at that time. The spectrographic velocity of Mars with reference to the earth was then 18.8 km. per second, recession. Unfavorable weather

passing down to the planet's surface. On the other hand, the rays did not, on the present occasion, pass through the planet's atmosphere at right angles to the strata, but the average angle of incidence and reflexion was about 20°.

[3] *Astrophysical Journal*, 5, 236, 1897.

delayed somewhat the carrying out of the program, but fortunately the velocity remained nearly constant for several weeks, until satisfactory observations were secured.

With the spectrograph adjusted for the orange region, which is rich in water vapor absorption, spectrograms of Mars were secured on January 26 and 27 under poor atmospheric conditions, and on February 2 under excellent conditions, our atmosphere on this night being exceedingly dry. Measures of the available water vapor lines on these spectrograms, 8 to 22 in number, establish that they were displaced with reference to the lines of solar origin in the observed Martian spectrum by amounts on the three dates corresponding to velocities in the line of sight of 19.7, 20.2 and 18.3 km. per second; weighted mean value, 19.2 km. The relative velocities of Mars, computed from our knowledge of the orbits of the earth and Mars, amounted to 19.1 km. per second. The dispersion and slit-width employed were such that the water vapor lines originating in our atmosphere and any originating in Mars's atmosphere should have appeared side by side, though not clearly separated. If the absorptions by the two planets were equal, the two sets of lines of equal intensities should, in effect, have appeared as broad lines of double width, and the measured velocities should have been but half the computed velocities. The facts are that the terrestrial lines were not bordered nor increased in width by companion lines. When the micrometer wire was set successively in the positions which Martian absorption lines would occupy, no traces of absorption were found in these positions. In effect, Martian absorption did not exist to such an extent as to be visible in the spectrum, or to influence the measurements referred to.

With the spectrograph adjusted to the so-called "alpha" region at λ 6280, which includes a large number of oxygen absorption lines, two spectrograms were obtained on February 3. The observable oxygen lines, seven and six in number, were displaced with reference to the lines of solar origin by amounts corresponding to velocities in the line of sight of 18.8 and 17.4 km. per second. The velocity computed from the elements of the orbits amounted to 19.1 km. The discrepancy of 1.0 km. is within the unavoidable error of measurement. Here again the terrestrial oxygen lines were not bordered nor doubled in width by Martian lines.

The conclusions to be drawn from this investigation are: The quantity of any water vapor existing above unit area in the equatorial atmosphere of Mars was certainly less than one fifth that existing above Mt. Hamilton under the excellent conditions prevailing on February 2. The air temperature was 0° Centigrade, the relative humidity 33 per cent., the absolute humidity 1.9 grams per cubic meter, and the zenith distance 55°.

Likewise, the quantity of oxygen above unit area of Mars must be small in comparison with that in the earth's atmosphere.

It should be repeated that the rays of light utilized had passed in effect twice through the Martian atmosphere.

W. W. Campbell,
Sebastian Albrecht

Lick Observatory,
University of California,
April, 1910

SOCIETIES AND ACADEMIES

THE AMERICAN PHILOSOPHICAL SOCIETY

At the meeting of the American Philosophical Society, on May 20, the following paper was read:

On the Principle of Relativity and its Significance: Dr. Robert H. Hough, University of Pennsylvania.

The question was considered only in its philosophical aspect. The idea was developed from the fundamental concepts of dynamics as formulated by Newton and Hertz, and extended to the field of electro-dynamics and optics. The validity of the principle as a mathematical concept was maintained. The equations of transformation were derived by purely mathematical steps from two initial equations representing experimental laws to the present probable error of observation: and the consequent relations of the distances and times involved and their respective units considered.

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